Utilization of Robotics Flipped Instruction to Students Learning Outcomes

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***Abstract –** With the COVID-19 pandemic, teaching highly skilled subjects such as robotics becomes a huge challenge, especially where schools are bound for distance learning. The study utilized the robotics flipped instruction in the hybrid online learning with the synchronous and asynchronous mode of delivery – a screen-to-screen teaching and learning process where students can work online and offline depending on their availability. Based on the findings of the study, the robotics flipped instructional model A-P-P-E-A-R was developed. Assess, plan, and program are part of the asynchronous or out-of-class activities whereas execute, analyze, and re-assess are part of the synchronous or in-class activities.*

The study concluded robotics flipped instruction is an effective alternative teaching strategy since there was an improvement in the students' learning outcomes. Consequently, students under the robotics flipped instruction perform better in terms of motivation and achievement. Moreover, results showed that female students are more extrinsically motivated while male students are more intrinsically motivated. Furthermore, the effectiveness of robotics flipped instruction revealed a between medium to large effect size. This implies a greater magnitude of the effect of the flipped learning environment in a robotics class. However, respondents of the study experienced several challenges in using flipped robotics instruction. These include (1) use of technology (2) delivery of instruction (3) targeting content and performance standards (4) preparation time and (5) internet connectivity.

***Keywords –** educational robotics, flipped classroom, online learning*

INTRODUCTION

The COVID-19 pandemic brought drastic changes that affected all aspects of human life. The education sector is one of the most affected by the "no contact policy" to minimize the transmission of the virus. Educational institutions then rushed to distance education, remote teaching, and online learning to continue educating the learners amidst the pandemic [1]. Without clear policy and guidelines, challenges arise such as curriculum, instruction, and assessment, particularly in online classes. It also includes sudden pedagogical transition that is found to be challenging for teachers, students, and stakeholders [2]. Since the field of education was forced to change its landscape to be relevant and responsive to the "new normal", school leaders, educators, and classroom teachers are compelled to rethink and redesign to address these challenges and seek opportunities.

Many educational systems are contemplating responsive approaches to implement the curriculum and redefine the approaches to instructional implementation [3]. While technology has a part to play, it is important to note that it is effective teaching that makes the difference. Pedagogy is the key to effective learning and should be explored in this new era of teaching and learning. In the Philippines, the basic education learning continuity plan is the response of the Department of Education (DepEd) to the challenges posed by COVID-19. Distance learning also called distance education, e-learning, and online learning is a form of education in which the main elements include physical separation of teachers and students during instruction and the use of various technologies to facilitate student-teacher and student communication [4].

Robotics is a highly skilled subject that must be taught engagingly – one that would allow students to apply their newfound knowledge and skills into projects and activities that would exhibit their learning. Lai [5] suggested that motivation can be manipulated through certain instructional practices. Teachers need to identify the different factors that affect the students' motivation to be able to sustain and further develop it. [6]. Likewise, it is essential in designing teaching instruction and pedagogy. Teaching robotics which includes robot assembly and programming is challenging especially now where online modality is used in most educational institutions. [7] suggested a blended approach as an ideal model for e-learning. Flipping the classroom using the hybrid learning model in teaching robotics is worth exploring. This technology-based strategy involves designing online activities for students, synchronously or in-class (during class) and asynchronously or out-of-class (before class). By extension, this means that students study instructional materials and perform activities during asynchronous learning and apply knowledge and skills from these materials during synchronous learning in an online flipped classroom.

Flipping the traditional way of teaching means shifting to an active learning process [8] in which the method is mostly student-centered and focused on the learning process [9]. In a flipped classroom, students study instructional material before class and apply this material during class [10]. Running the traditional classroom in reverse, hence, the name inverted classroom. Literature also revealed that flipped classrooms allow for better utilization of class time through practical works, applications, and laboratory activities rather than inactive lectures [9], [11], [12], allowing more class time for hands-on activities done collaboratively to promote social interaction [13]-[14] and use of class time to deepen their understanding in an engaging approach, discussion, and application in the problem-solving activities [15]-[16]. These advantages, however, involved the face-to-face modality of teaching. This study explores utilizing the flipped classroom in online teaching using a hybrid model with synchronous and asynchronous learning.

Though many studies have been conducted regarding the flipped classroom, there is not sufficient result on the impacts of the online flipped classroom on the performance and motivation of students in robotics. This study will help contribute to the existing literature in teaching in a flipped classroom environment – converting traditional instruction into flipped instruction. It was hoped that the robotics flipped instruction would help achieve better performance and higher motivation among students and develop an instructional model for teachers who are willing to explore the alternative teaching strategy.

OBJECTIVES OF THE STUDY

This paper examined the effects of using a flipped classroom environment in teaching robotics online. Specifically, this study aims to shed light on the following questions: (1) What are the students' learning outcomes before and after the use of flipped instruction in robotics in terms of performance and motivation? (2) Is there a significant difference in the learning outcomes before and after the use of flipped instruction in robotics in the aforementioned variables? (3) What challenges are encountered on the use of flipped instruction in robotics based on the perspectives of students and teachers? (4) What virtual instructional model can be developed?

MATERIALS AND METHODS

Design

The study employed the one-group pretest-posttest design. This is a quasi-experimental research design in which the same dependent variable is measured in one group of participants before (pretest) and after (posttest) treatment is administered [17].

Participants

The researcher employed purposive sampling to recruit participants who were willing to participate, and at the same time had the information needed for the study [18]-[20]. To initiate the study, the following conditions were established: (1) Participants must be teachers or learners in a public school (DepEd – NCR); (2) participants must be teachers and learners in the junior high school level, and (3) participants must be involved in the robotics program in their school. The participants were selected using homogeneous sampling. This type of nonprobability sampling aims to achieve a homogeneous sample whose units share the same characteristics of the particular group of interest [19]. Thirteen (13) DepEd junior high schools participated in the study. Seven of which are science high school and the remaining six are a regular high school. Twenty-six teachers (26) and four hundred eight (408) students constitute the four hundred thirty-four (434) respondents in the study.

Instruments

To measure the learning outcomes, two research instruments were given to the student participants before and after utilizing robotics flipped instruction. First, the achievement test in which items were taken from the VEXcode VR [released test questions], a standardized test used in online robotics education. To ensure its appropriateness for measuring the desired skills and concepts that have been covered within the conduct of the study, the researcher chose only fifty (50) items. These items were in multiple-choice format taken within 60 minutes. Each item has four choices and one keyed answer. It specifically measures the performance of the students before and after [pretest posttest] using the robotics flipped instruction. Second, the Robotics Motivation Questionnaire II (RMQ II) adapted from the works of Glynn et al [21] was utilized to assess students' motivation. It is a 5-Likert scale survey consisting of twenty-five (25) statements and with Cronbach's alpha of 0.92. The researcher chose only the 10 items specifically pertaining to intrinsic and extrinsic motivations to determine the learning outcomes of the students in robotics flipped instruction. In order to better understand what they think and how they feel about the robotics flipped instruction, participants responded to the statements from the perspective of "When I am in robotics class…" The following are the interpretations of the ratings using the Likert scale in the motivation questionnaire: 4-Always, 3-Often, 2-Sometimes, 1-Rarely, and 0-Never.

A third survey questionnaire was used to determine the demographic profile as well as the challenges encountered by the student and teacher respondents in using the robotics flipped instruction. The following are the interpretations of the ratings using the 5-Likert scale: 5-very large extent, 4-large extent, 3-moderate extent, 2-little extent, and 1-no extent at all. Research instruments were validated by five (5) experts: professor, principal, headteacher, robotics coach, and robotics teacher for contextualization. Revisions were made based on the comments and suggestions of the validators.

Procedure

The researcher programmed the survey questionnaire in Google forms. Then, the link to the Google forms was distributed to selected participants via private messages. Responses were automatically generated in excel file format for data analysis. The data gathered were utilized to investigate the effects of the robotics flipped instruction on students learning outcomes. The implementation was carried out over eight weeks in the second quarter of the school year 2020-2021. Likewise, participants were oriented on the flipped classroom environment.

Moreover, quantitative data were collected at different times to measure the learning outcomes of the students in the robotics flipped instruction. Students' performance was measured through their mean scores in the pretest and posttest. The tests were administered in online mode. Similarly, participants' level of motivation was assessed online using the RMQ II before and after the intervention.

Analysis

The researcher utilized the Statistical Package for the Social Sciences (SPSS), a software package used for statistical analysis. T-test for a paired sample was used to test if there is a significant difference in the mean scores of students before and after the use of robotics flipped instruction. To measure the effect size, Cohen's d for independent samples t-tests (between group design) was utilized using the equation, $d = \frac{2\text{t}}{\sqrt{n}}$.

Alternatively, the level of motivation in learning robotics in a flipped environment was determined using descriptive analysis. It involved descriptive statistics specifically, the measures of frequency and central tendency. The same method was used to analyze the data for the challenges encountered by the respondents in using the robotics flipped instruction.

Ethical Consideration

To participate in this study, respondents were asked to submit a signed informed consent form and parental consent as applicable. Consent forms indicated the purpose of the study, the rights and roles of participants, and the statement of confidentiality to protect the participants' right to privacy. At any point during the conduct of the study, respondents may choose to discontinue their participation.

RESULTS AND DISCUSSION

Table 1 shows that students scored higher in the post-test (M=31.26) than in the pretest (M=28.65). Moreover, the increase in the mean scores between pretest and posttest is attributed to the use of the alternative teaching strategy. This means that students perform better with flipped robotics instruction. Several researchers agree that active learning – or variations referred to as interactive instruction, experiential learning, or "learning by doing" – has resulted in positive learning outcomes [9].

Table 1. Pre-Post Mean Scores

	N	Mean	SD	Std. Error Mean
Pretest	408	28.65	3.57	.177
Posttest	408	31.26	3.84	.190

Danker [15] concluded that flipped classrooms had a promising impact on student learning and achievement. In the literature, as observed in this study, it was found that the flipped classroom approach increases the academic ability of students. Asiksoy and Ozdamli [16] revealed that flipped classroom approach when adapted to the Attention, Relevance, Confidence, and Satisfaction (ARCS) motivation model in teaching a particular physics course has a more positive effect than the traditional approach. In addition, Hung's [22] study on flipped classroom had positive effects on academic achievement, attitude, and lesson participation levels of students. Accordingly, flipped classroom helps in developing information literacy and critical thinking skills through domain knowledge learning in digital classrooms [23]. However, several studies found no increase in the achievement of the students using a flipped-classroom approach, when compared with the traditional approach. According to Cabi [24], students resist learning the topics on their own outside the classroom instead they prefer learning topics from the instructor inside the class. Among other problems were lack of time to study outside the class, difficulty in understanding the topics, and learning difficulty. The study of Frydenberg [25], revealed that a smaller class size and a classroom with table rather than rows of fix seating is more conducive for implementing FC. The ability for the instructor to circulate among the students is crucial to their success. Winter [26] found that some students were reluctant to engage in the discussion-oriented activities. Also, teachers often feel uncomfortable in their new role as a facilitator.

While intrinsic motivation is performing a task for its own sake, motivation to perform a task as a means to an end such as good grades is extrinsic. According to Cerasoli [27] intrinsic and extrinsic motivations are equally vital for performance. Both types of motivation are important in contributing to students' success in their courses or subjects [28], [6].

Before the intervention, the extrinsic motivation of male students is greater than female students (M=2.383; M=2.197) and their intrinsic motivation is less than their opposite (M=2.214; M=2.336). After the intervention, reverse results were obtained: the extrinsic motivation of the female students is higher than the male students (M=3.842; M=3.708) and their intrinsic motivation is lower than their opposite (M=2.495; M=2.57). This result is like the study of Naval [6] where male and female students are found to be motivated differently using practical works in teaching physics.

The study revealed that males were seen to be intrinsically motivated being satisfied and personally interested in robotics while females were extrinsically motivated by grades. Male students find learning robotics interesting, relevant in their lives, meaningful, boosts their curiosity and that they find it enjoyable. On the other hand, female students focus on getting high grades in learning robotics and performing better than others.

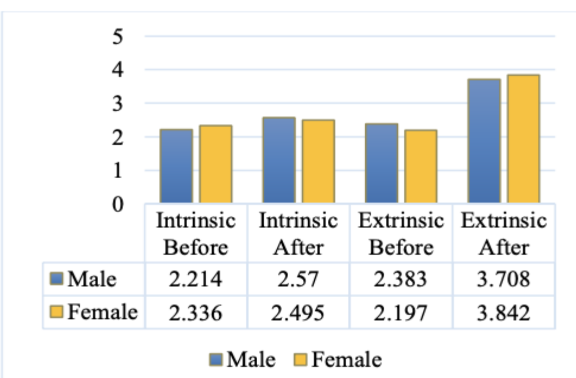

Fig. 1. Types of motivation.

With the flipped classroom environment, students' motivation to learn robotics increased. Theodoropoulos et al [29] corroborated that educational robotics strengthens the intrinsic motivation of the learners in his study on learning Computer Science. Afar and Khine [30] stated that to increase the learners' motivation and catch their attention, it is necessary to involve technology in the process of learning especially in the 21st-century learning environment.

Furthermore, the higher mean scores in the posttest mean that students are more extrinsically motivated to learn robotics. Tugun et al [31] showed similar findings that students have positive views about environments in which the flipped classroom learning method is applied; they feel happy about the lectures taught with the flipped classroom learning method and they prefer the flipped classroom model.

A paired samples test was conducted to compare mean scores in pretest and posttest. There was a statistically significant difference in the scores for pretest (M=28.65, SD=3.57) and posttest (M=31.26, SD=3.84) conditions; t (203) = -11.35, p = 0.000. These results suggest that robotics flipped classroom really does have an effect on students' performance. Specifically, the results suggest that when a flipped classroom is applied in robotics class, students perform better.

Table 2. Significance Level of Pre-Post Mean Scores

	Paired Differences							
	Mean	SD	Std. Error Mean	95% Confidence Interval of the Difference		*t*	*df*	*p-value*
				Lower	*Upper*			
Pretest - Posttest	-2.61	4.65	.230	-3.06	-2.16	-11.34	407	.000

From the given table, the computed p-value is less than the 0.05 level of significance. Therefore, there is a significant difference between the mean scores of the pretest and posttest. This means that using flipped robotics instruction promotes learning and that students perform better. Most experts agree that students learn best when they take an active role in the education process, discussing what they read, practicing what they learn, and applying concepts and ideas.

Researchers agree with the result of the study that the flipped classroom increases students' academic success [32]-[35]. By making time for more learning activities, the flipped classroom accommodates closer interaction between teachers and students which in turn improves students' academic achievement and persistence [36]. According to Låg and Sæle [8], the evidence is accumulating that teaching for active learning leads to better student performance and lower failure rates than lecture-based teaching [37].

Cabi [24]'s study results, however, showed that there were no statistically significant differences between the scores of the two groups and that flipped classroom does not yield significant impacts on increasing the students' academic achievement. Few other studies support this finding [38]-[39].

To determine how effective the robotics flipped instruction is in terms of effect size, Cohen's d was used. It is an appropriate effect size for the comparison between two means. It was used to describe the results in terms of measures of magnitude. From the data gathered, computed d = - 0.704. Based on Cohen's convention, the computed value is considered between medium to large effect size. Effect size is a quantitative measure of the magnitude of the experimenter effect. The larger the effect size the stronger the relationship between the two variables.

Tugun et al [31]'s study showed the same result, the success rate of the experimental group students in flipped classroom education was higher than the control students learning in a traditional method. Similarly, comparing the flipped classroom with traditional teaching revealed small summary effect size estimates on student learning in favor of the flipped classroom according to the study of Låg, and Sæle, [8].

The level of the intrinsic and extrinsic motivations of the students in both groups increased. However, the difference in increase of the level of motivation is different as shown in figure 2.

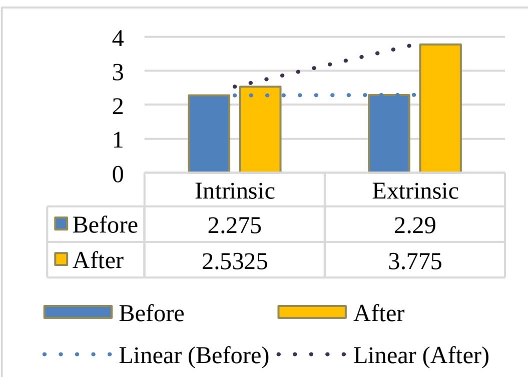

Fig. 2. Level of motivation.

Students *sometimes* think and feel that they are intrinsically and extrinsically motivated when they are in the robotics class. After the intervention, participants *often* and *always* think and feel that they are motivated intrinsically (M=2.53) and extrinsically (M=3.78) respectively. Students are more extrinsically motivated as reflected in their posttest scores in learning robotics in a flipped classroom environment. Conversely, students are less intrinsically motivated in the flipped classroom. Låg and Sæle [8] states that the elements such as preparation, tests, and activities that supposedly should enhance learning are also likely to entail a larger workload on students. These activities are done remotely during asynchronous as preparation for the synchronous session which could affect outcomes, in particular student motivation.

Motivation is essential in designing teaching instruction and pedagogy. Gillet et al[40] articulated that knowing the different variables that influence academic performance is necessary to improve not just the teaching strategies but also the learning process. Therefore, in order to sustain and further develop learners' motivation, it is necessary for teachers to be able to identify the different factors that affect it. Motivation can be manipulated through certain instructional practices [5]-[6]. In this study, the increase in motivation of students is attributed to the use of robotics flipped instruction. The same results were observed by Tugun et al [31] that the application of the flipped classroom education method increased the motivation of students. Correspondingly, Aşıksoy, and Ozdamli [16] found that the experimental group students achieved more than the students in the control group as well as an increase in motivation and self-sufficiency of the students.

Moreover, the results of the study showed that students are more extrinsically motivated to work on tasks to attain a desirable outcome such as a good grade as reflected in their scores in the posttest. This is similar to the study of Gillet et al [41] which explained that teachers and parents frequently stress the importance of academics for future endeavors more than conveying that learning can be fun. Diseth et al [42] justified that extrinsic motivation fuels high school students' behavior and academic performance since intrinsic motivation was found to decline at this age range.

Both teachers and students were asked regarding the challenges they encountered in teaching and learning robotics. Figure 3 revealed the different experiences of respondents using robotics flipped instruction in terms of (1) use of technology (2) delivery of instruction (3) targeting content and performance standards (4) preparation time and (5) internet connectivity.

Teachers agreed to a moderate extent (M=3.45) that the main concern in flipping the class is time. Structuring and designing both out-of-class and in class activities take longer preparation time compared to traditional instruction. According to Jang and Kim [43], the planning of in-class activities does require much more preparation than anticipated in advance. Students also find time as a challenge to a moderate extent (M=3.07). Students reported that the time in accomplishing activities asynchronously as well as screen time increases with the flipped classroom. However, Fetaji et al [44] mentioned that most students' attention is unconsciously getting diverted to surfing the internet for other matters such as online games and social media. The same result was yielded in the study of Illie et al [45] where increased time is one of the disadvantages in the flipped classroom. According to [12], the flipped classroom does require extra effort on planning and preparation for teachers while students need to allow extra time for learning such as watching lessons outside class hours [46]. Unlike traditional instruction, preparation for the in-class activities is expected in robotics flipped instruction. Materials are posted online for their reference, exercises and quizzes are given as formative assessments, and videos are provided for effective visualization and programming. In the study conducted by Cabi [24], coming to classes prepared and completing the assignments in class are the positive aspects of the flipped classroom model. This also promotes self-efficiency and self-directed learning [47].

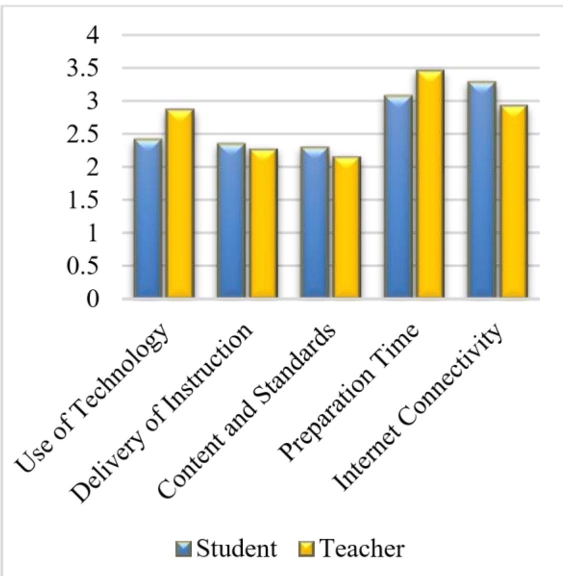

Fig. 3. Challenges in robotics flipped instruction.

The lack of internet access or the poor internet connection was reported to be a moderate extent (M=3.28, M=2.92) by both students and teachers as a challenge in robotics flipped instruction. According to [48], not everyone can afford an internet connection or fully access various online materials that are needed. This is consistent with the majority of the students taking online classes other than robotics since the quality of the output and efficiency are affected. Teachers all over the country shared the same struggle as they prepare the learning materials asynchronously and use them in synchronous meetings. According to Salac and Kim [49], the Philippines had a meager average internet speed of 2.8 Mbps and lags behind contemporary developing countries in Asia in terms of internet connectivity. Similarly, unreliable internet connections and out-of-date devices are indeed a challenge for online distance modality [50].

The use of technology seemed to be more challenging to teachers than students (M=2.86, M=2.41). With emergency remote teaching, teachers need to equip themselves with the use of technology. Though there are pieces of training provided for teachers before the start of the school year, the actual teaching in an online platform is a first for most of them. Hence, there is still the fear of using technology. According to Mandinach and Cline [51], educators go through four (4) stages of development with their use of technology: survival, mastery, impact, and innovation. Fetaji et al [44] stated that technology is a fundamental part of a flipped classroom, and that the integration of technology can improve student motivation in classroom instruction. Since robotics focuses on developing skills, the use of technology is a necessity. Teachers need to develop confidence and competence in the use of technology for transformational and active learning to happen.

Both teacher and student respondents agreed that targeting the content and performance standards (M=2.14, M=2.29) as well as delivery of instruction (M=2.26, M=2.34) were of little extent as a challenge in robotics flipped instruction. According to Berry [11], flipped classroom in robotics class is worth it because the discussion is more in-depth, and students perform better in the given task. The learning content and activities prepared by the teachers are well received by the students. This means that the level of difficulty of the lessons matches that of the learning competencies students need to acquire. In flipped classroom robotics class, appropriate and timely feedback, easy-to understand materials, and assessments ensure a successful learning process [12]. The strategy used, robotics flipped instruction, worked well for both students and teachers. This means that the alternative way of teaching robotics did facilitate the teaching and learning process in hybrid online classes.

In flipping the robotics class, the A-P-P-E-A-R virtual instructional model was developed. Figure 4 shows the steps on how to use the virtual instructional model in a flipped robotics classroom environment.

Assess, plan, and program are part of the asynchronous or out-of-class activities whereas execute, analyze, and re-assess are part of the synchronous or in-class activities. First, assess - with the materials and resources provided in the learning management system (LMS), students' understanding of the concepts is assessed formatively. This step helps the teacher in recognizing the needs, addressing them, and bridging the gaps. Second, plan - the teacher prepares specific learning activities with clear objectives. Planning also involves organizing and strategizing meaningful activities that enhance students' higher order thinking skills. Third, program - creating programs and testing them out to solve a given problem provides meaningful learning engagement. Students work remotely either independently or collaboratively while the teacher communicates with the students thru the LMS. These serve as their practice to develop the necessary skills needed for the in-class activities. Fourth, execute – performance tasks will be given to the class during the synchronous session. Here, students are expected to demonstrate their knowledge and skills as they attempt to solve the problem through programming and collaboration, sometimes in the form of simple competition. Fifth, analyze - feedback and comments are then given to the students while analyzing their output for improvement. The teacher facilitates and guides them through breakout rooms in video conferencing. Sixth, re-assess - students' final output will be re-assessed during their presentation (summative assessment) using rubrics and a set of criteria.

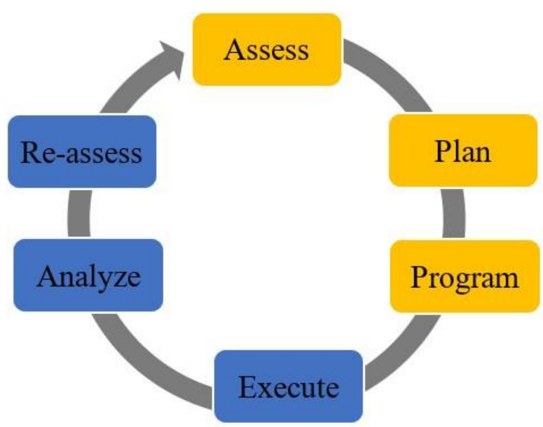

Fig. 4. A-P-P-E-A-R instructional model.

According to Keh et al [52], it is essential to develop an educational pedagogy that is founded in robotics and other educational technology to keep up with the trend of the continuously changing world. In transitioning into a flipped classroom careful planning and flexibility on the part of the teacher are expected [53]. Yanjie et al [54] require that the teacher is an expert in the content while taking into account the ability of the learners [55]. According to Marks [56], it is also important to design and organize materials in LMS.

The result of the present study agreed with the works of Herreid et al [57] which revealed that a flipped classroom environment renders better use of class time and flexible technology, and that of Ortiz [58] in which robotics boosts learners' motivation through continuous practice of programming and related skills. Several studies have shown how instruction in a flipped classroom environment shapes the outcomes of a robotics class: It excites the learners through competition, provide hands-on experience, and develop skills in computational thinking [44]; It fosters a more in-depth discussion and better performance [11]; It is a successful learning process combined with prepared materials for ease of understanding, providing appropriate and timely feedback, and series of formative assessments to check understanding [12].

The A-P-P-E-A-R virtual instructional model of the robotics flipped instruction creatively helped students to manage their learning through the use of technology with the teacher as facilitator. Moreover, the student's level of motivation and academic achievement also increased. The same results were found by Kazez, and Genç [59] that with the use of technology - Lego and robotics, students' motivation and self-confidence increased.

CONCLUSION AND RECOMMENDATION

In the utilization of the robotics flipped instruction, students' performance and motivation, both intrinsic and extrinsic increased. The study also revealed that there is a significant difference between the mean scores of the pretest and posttest. This signifies that students perform better using the robotics flipped instruction. Furthermore, the effectiveness of flipped robotics instruction revealed a between medium to large effect size. This implies a greater magnitude of the effect of the flipped learning environment in teaching robotics online.

Challenges that are encountered in robotics flipped instruction include preparation time and internet connectivity to a moderate extent. Respondents of the study agreed to have the challenges regarding the use of technology, delivery of instruction, and targeting content and standards to a little extent in utilizing robotics flipped instruction. However, teachers are more technologically challenged than students.

Using the robotics flipped instruction, the virtual instructional model developed in the study is called A-P-P-E-A-R which stands for assess, plan, program, execute, analyze, and re-assess. Assess, plan, and program are part of the asynchronous or out-of-class activities whereas execute, analyze, and re-assess are part of the synchronous or in-class activities. The A-P-P-E-A-R virtual instructional model of the robotics flipped instruction creatively helped students to manage their learning through the use of technology with the teacher as facilitator.

It is recommended that the robotics flipped instruction be more prevalent in educational institutions with robotics programs as an alternative teaching strategy in teaching robotics. Similar studies might be conducted with a longer interval between pretest and posttest. Applications of the flipped classroom should be carried out effectively by all teachers across disciplines in all levels of education using the hybrid online with synchronous and asynchronous modality in teaching and learning. It is also recommended to use the A-P-P-E-A-R instructional model in the teaching and learning process to test and validate curricula and methodologies at the school class level, teacher education, and the field of educational research.

REFERENCES

[1] Guangul, F. M., Suhail, A. H., Khalit, M. I., & Khidhir, B. A. (2020). Challenges of remote assessment in higher education in the context of COVID-19: a case study of Middle East College. *Educational assessment, evaluation and accountability*, 1–17. Advance online publication. doi:10.1007/s11092-020-09340-w

[2] Langegård, U., Kiani, K., Nielsen, S. J., & Svensson, P. (2021). Nursing students' experiences of a pedagogical transition from campus learning to distance learning using digital tools. *BMC Nursing, 20*(1). doi: 10.1186/s12912-021-00542-1

[3] Cahapay, M. (2020). Reshaping assessment practices in a Philippine teacher education institution during the coronavirus disease 2019 crisis. *Pedagogical Research, 5*(4).

[4] Berg, G. A., & Simonson, M. (2016). Distance Learning. *Encyclopedia Britannica*. https://www.britannica.com/topic/distancehttps://www.britannica.com/topic/distance-learninglearning

[5] Lai, E. R. (2011) Motivation: A Literature Review. *Pearson Research Report.* https://images.pearsonassessments.com/images/tmrs/Motivation_Review_final.pdf

[6] Naval, D. J. (2020). Practical work: Its effects on performance and motivation of non-physics major students. *International Journal of Research Studies in Education, 9*(1), 99-108. doi: 10.5861/ijrse.2020.5801

[7] Shank, D. B. (2020). What is digital sociology? *Contemporary Sociology, 49*(2), 204–205. doi: 10.1177/0094306120902418mm

[8] Låg, T., & Sæle, R. G. (2019). *Study Level Data for Does the Flipped Classroom Improve Student Learning and Satisfaction? A Systematic Review and Meta-Analysis* [Dataset]. Data verse NO, V1. doi: 10.18710/QA8WBZ

[9] Uran, K. (2018), Increased student learning through the flipped instruction model. *Culminating Projects in Information Media. 18*. https://repository.stcloudstate.edu/im_etds/18.

[10] van Alten, D. C., Phielix, C., Janssen, J., & Kester, L. (2019). Effects of flipping the classroom on learning outcomes and satisfaction: A meta-analysis. *Educational Research Review28*, 10.1016/j.edurev.2019.05.003

[11] Berry, C. A. (2017). Robotics education online flipping a traditional mobile robotics classroom. *2017 IEEE Frontiers in Education Conference (FIE)*. doi: 10.1109/fie.2017.8190719

[12] Okamura, E. R. (2018). Action research on flipped robotics instruction. 22nd Annual Technology, *Colleges and Community Worldwide Online Conference.* http://hdl.handle.net/10125/55885

[13] Abeysekera, L., & Dawson, P. (2015). Motivation and cognitive load in the flipped classroom: Definition, rationale and a call for research. *Higher Education Research and Development, 34*, 1–14. doi:10.1080/07294360.2014.934336

[14] Foldnes, N. (2016). The flipped classroom and cooperative learning: Evidence from a randomised experiment. *Active Learning in Higher Education, 17*(1), 39–49. doi: 10.1177/1469787415616726

[15] Danker, B. (2015). Using flipped classroom approach to explore deep learning in large classrooms. *IAFOR Journal of Education, 3*(1). doi: 10.22492/ije.3.1.10

[16] Aşıksoy, G. & Ozdamli, F. (2016). Flipped classroom adapted to the ARCS model of motivation and applied to a physics course. *EURASIA Journal of Mathematics, Science & Technology Education. 12.* 1589-1603. 10.12973/eurasia.2016.1251a.

[17] Privitera, G. J., & Ahlgrim-Delzell, L. (2018). *Research Methods for Education.* SAGE Publications.

[18] Etikan, I., & Bala, K. (2017). Sampling and sampling methods. *Biom Biostat Int J. 5*(6), 215-217. doi: 10.15406/bbij.2017.05.00149

[19] Favila, S. A., Erfe, J. P., Pimentel, M. M., Naval, D. J., Rabina, M. G., Castro, L. A., & Macascas, C. D. (2019). UGNAYAN: A proposed knowledge sharing model for senior high school work immersion program. *The Normal Lights, Journal on Teacher Education, 13*(2), 111-131.

[20] Taherdoost, H. (2016). Sampling methods in research methodology: How to choose a sampling technique for research. *SSRN Electronic Journal.* doi: 10.2139/ssrn.3205035

[21] Glynn, S. M., Brickman, P., Armstrong, N., & Taasoobshirazi, G. (2011). Science Motivation Questionnaire II: Validation with science majors and non-science majors. *Journal of Research in Science Teaching 2011, 48*, 1159-1176.

[22] Hung, H. (2014). Flipping the classroom for English language learners to foster active learning. Computer *Assisted Language Learning, 28*(1), 81-96. 10.1080/09588221.2014.967701

[23] Kong, S. C. (2014). Developing information literacy and critical thinking skills through domain knowledge learning in digital classrooms: An experience of practicing flipped classroom strategy. *Computers & Education, 78,* 160-173. doi: 10.1016/j.compedu.2014.05.009

[24] Cabi, E. (2018). The impact of the flipped classroom model on students' academic achievement. The International Review of Research in Open and Distributed Learning, 19(3). doi: 10.19173/irrodl.v19i3.3482.

[25] Frydenberg, M. (2012). Flipping excel. 2012 *Proceedings of the Information Systems Educators Conference, 1*-1, New Orleans: EDSIG.

[26] Winter, J. B. (2013). *The Effect of the Flipped Classroom Model on Achievement in an Introductory College Physics Course.* [Master's Thesis, Mississippi State University].

[27] Cerasoli, C. P., Nicklin, J. M., & Ford, M. T. (2014). Intrinsic motivation and extrinsic incentives jointly predict performance: A 40year meta-analysis. *Psychological Bulletin, 140*(4), 980-1008. doi: 10.1037/a0035661

[28] Deci, E. L., & Ryan, R. M. (2010). Self-determination. New York, NY: *John Wiley & Sons, Inc.* 10.1002/9780470479216.corpsy0834

[29] Theodoropoulos, A., Antoniou, A., & Lepouras, G. (2017). Teacher and student views on educational robotics: The Pan-Hellenic competition case. *Application and Theory of Computer Technology, 2*(4), 1.10.22496/atct.v2i4.94

[30] Afari, E., & Khine, M. S. (2017). Robotics as an educational tool: Impact of lego mindstorms. *International Journal of Information and Education Technology, 7*(6), 437-442. doi: 10.18178/ijiet.2017.7.6.908

[31] Tugun, V., Uzunboylu, H., & Ozdamli, F. (2017). Coding education in a flipped classroom. *TEM Journal, 6*(3), 599-606. 10.184210.18421/TEM63-23

[32] Janotha, B. (2016). Improving student achievement with flipped classroom pedagogy. *Nursing Research, 65*(2), E100-E101. http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=113905419&site=ehost-live

[33] Pierce, R., & Fox, J. (2012). Vodcasts and active-learning exercises in a “flipped classroom” model of a renal pharmacotherapy module. *American Journal of Pharmaceutical Education, 76*(10), 196. 10.5688/ajpe7610196

[34] Talley, C. P., & Scherer, S. (2013). The enhanced flipped classroom: Increasing academic performance with student-recorded lectures and practice testing in a "flipped" stem course. *The Journal of Negro Education, 82*(3), 339-347. 10.7709/jnegroeducation.82.3.0339

[35] Zengin, Y. (2017). Investigating the use of the khan academy and mathematics software with a flipped classroom approach in mathematics teaching. *Journal of Educational Technology & Society, 20*(2), 89-100. http://www.jstor.org/stable/90002166.

[36] Robinson, C. D., Scott, W., & Gottfried, M. A. (2019). Taking to the next level: A field experiment to improve instructor-student relationships in college. *AERA Open, 5*(1), 1–15. doi: 10.1177/2332858419839707

[37] Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences of the U S A, 111,* 8410–8415. doi:10.1073/pnas.1319030111

[38] Kim, M., Kim, S., Khera, O., & Getman, J. (2014). The experience of three flipped classrooms in an urban university: An exploration of design principles. *Internet and Higher Education, 22*, 37-50.

[39] Smallhorn, M. (2017). The flipped classroom: A learning model to increase student engagement not academic achievement. *Student Success, 8*(2). doi: 10.5204/ssj.v8i2.381 [40] Sanz, N. M., Inés, R. G., Garcia, C. I., & Pastrana, P. A. (2017). Exploring academic performance: Looking beyond numerical grades. *Universal Journal of Educational Research, 5*(7), 1105-1112. 10.13189/ujer.2017.050703

[41] Gillet, N., Vallerand, R. J., & Lafrenière, M., K. (2012). Intrinsic and extrinsic school motivation as a function of age: the mediating role of autonomy support. *Social Psychology of Education: An International Journal, 15*(1), 77-95. doi: 10.1007/s11218-011-9170-2

[42] Diseth, Å., Mathisen, F. K., & Samdal, O. (2020). A comparison of intrinsic and extrinsic motivation among lower and upper secondary school students. *Educational Psychology, 40*(8), 961-980. doi: 10.1080/01443410.2020.1778640

[43] Jang, H., & Kim, H. (2020). A meta-analysis of the cognitive, affective, and interpersonal outcomes of flipped classrooms in higher education. *Education Sciences, 10*(4), 115. 10.3390/educsci10040115

[44] Fetaji, M., Fetaji, B., Gylcan, M., & Ebibi, M. (2016). "Case study analyses of the impact of flipped learning in teaching programming robots", *TEM Journal, 5*(4), 401-406. doi: 10.18421/TEM53-22.

[45] Illie, V. (2019). The flipped classroom. *Education Quarterly Reviews, 2*(2), Retrieved from https://ssrn.com/abstract=3415241

[46] Chen Hsieh, J. S., Wu, W. V., & Marek, M. W. (2016). Using the flipped classroom to enhance EFL learning. *Computer Assisted Language Learning, 30*(1-2), 1-21. 10.1080/09588221.2015.1111910

[47] Chyr, W. L., Shen, P. D., Chiang, Y. C., Lin, J. B., & Tsai, C. W. (2017). Exploring the effects of online academic help-seeking and flipped learning on improving students' learning. *Educational Technology & Society, 20*(3), 11–23. http://www.jstor.org/stable/26196116

[48] Dasig Jr., D. D. (2013). User experience of embedded system students on Arduino and Field Programmable Gate Array (FPGA). *Journal of Business, Education and Law, 18*(1). http://ejournals.ph/form/cite.php?id=10257

[49] Salac, R., & Kim Y. (2016). A study on the internet connectivity in the Philippines. *Asia- Pacific Journal of Business Review*. 10.20522/APJBR.2016.1.1.67

[50] Alruwais, N., Wills, G., & Wald, M. (2018). Advantages and challenges of using eAssessment. *International Journal of Information and Education Technology, 8*(1), 34-37.

[51] Mandinach, E. B., & Cline, H. F. (1994). *Classroom dynamics: Implementing a technology-based learning environment*. Routledge.

[52] Keh Jr., D. N., Rufo, L. A. N., Abundabar, C. G. P., Cadelinia, D. C. M. D., Donjuan, R. A., Ladic, J. R. D., Mendoza, M. R., & Morales, A. L. A. (2020). Boon or bane: The lived experiences of the robotics club members of Philippine school Doha at the onset of robotics. *International Journal of Research Publications, 62*(1). doi: 10.47119/ijrp1006211020201458

[53] Ng, W. (2014). Flipping the science classroom: Exploring merits, issues and pedagogy. *Teaching Science, 60*(3), 16-27.

[54] Yanjie S., Morris S. Y., Jong, Maiga C., & Weiqin C. (2017). Guest editorial: "HOW" to design, implement and evaluate the flipped classroom? – A synthesis. Journal of *Educational Technology & Society, 20*(1), 180- 183. www.jstor.org/stable/jeductechsoci.20.1.180

[55] Lo, C. K., & Hew, K. F. (2017). Using "First principles of instruction" to design mathematics flipped classroom for underperforming students. *International Journal of Learning and Teaching.* https://doi.org/10.18178/ijlt.3.2.82-89

[56] Marks, D. B. (2015). Flipping the classroom: Turning an instructional methods course upside down. *Journal of College Teaching & Learning, 12*(4), 241-248.

[57] Herreid, C. F., Schiller, N. A., Herreid, K. F., & Wright, C. B. (2014). A chat with the survey monkey: Case studies and the flipped classroom. *Journal of College Science Teaching, 44,* 75–80. https://www.jstor.org/stable/43631780

[58] Ortiz, A. (2015). Examining students' proportional reasoning strategy levels as evidence of the impact of an integrated LEGO robotics and mathematics learning experience. *Journal of Technology Education, 26*(2), 46-69.

[59] Kazez, H., & Genç, Z. (2016). Research trends in Lego and robotic usage in education: A document analysis. *Journal of Instructional Technologies & Teacher Education, 5*(1), 19-31.

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